Improving

COLLEGE AND UNIVERSITY

Teaching

TEACHING AN INTEGRATED COURSE IN THE BIOLOGICAL SCIENCES

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Per. rec'd
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THE STUDENT'S BACKGROUND AND COLLEGE TEACHING

George W. Gleeson
Dean of Engineering, Oregon State College

WHAT IS GOOD COLLEGE TEACHING?

Hobart F. Heller
Dean, Eastern Illinois State College

THE GOODLY FELLOWSHIP

"THESE BOOKS WERE STIMULATING"

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Improving College and University Teaching

The Student Must Swim

"The purpose of college teaching is to induce self-propelled intellectual activity on the part of the student."[1] The great Agassiz of Harvard placed in front of Nathaniel Shaler a small fish and told him to study it. On no account was he to talk with any one about it, nor read anything about fishes, until Agassiz gave him permission to do so. "Find out what you can without damaging the specimen; when I think that you have done the work I will question you." Agassiz's process of "self-education under guidance" took two weeks of ten-hour days, but the result astonished young Shaler and satisfied Agassiz.[2]

Shaler does not record any particular guidance that Agassiz gave him. He felt at first that Agassiz was simply neglecting him. At the stages when Shaler thought he had found out all he could about his specimen, Agassiz would comment, "That is not right." But Shaler became aware that Agassiz was covertly watching him; he was interested in his student.

Such interest in the student is a first mark of a teacher. A student works better, studies more, if he feels that his teacher takes appreciative notice of his activity. And learning is activity, "something which the individual *does*."[3] In getting the student to study, to think, to retain, to apply, the teacher is frequently baffled. He may also be challenged. But there is no escape. He cannot learn for the student. He can only provide the subject matter, uncover it, try to make it alluring, show its significance. He can beckon, prod, guide. The measure of his teaching still will be what the student *does*. If what he does consists merely of memorizing, regurgitating, and then forgetting, the learning is of a low order. If the student becomes largely activated, building the subject matter into the tissue of his intellectual, emotional, and volitional life, the learning is of the highest order. It can then be said as truly that the teaching also is of the highest order.

At the fountain of learning, the student must do more than merely taste or merely drink. He must plunge in unreservedly. He must swim.[4]

1 American Association of University Professors. *Report of the Committee on College and University Teaching.* Washington, D. C.: Bulletin of the American Association of University Professors. 1933. Page 17.

2 Houston Peterson. *Great Teachers.* New Brunswick: Rutgers University Press. 1946. Chapter XIII by Nathaniel Southgate Shaler.

3 John Dewey. *Democracy and Education.* New York: The Macmillan Company. 1916. Page 390.

Welcome

The initial issue of Improving College and University Teaching without advance announcement was dropped like a pebble into the academic ocean. The response has been cordial and encouraging. Subscriptions are mounting daily and at time of going to press for this second issue represent thirty-two states, Alaska, District of Columbia, and Canada.

Subscribers have commended the journal and expressed confidence in its continued usefulness: "Will fulfill a long-standing need." "Just what I need to keep in touch with ideas on teaching." "Solidly profitable and professionally enjoyable." "A constructive venture." "Will speed along the movement to improve college teaching." "Something we can really apply to the job at hand."

Featuring articles on teaching written by teachers, Improving College and University Teaching will be open to all members of college and university faculties who, from their knowledge, thinking, and experience, are ready to share in the continued improvement of teaching in both undergraduate and graduate schools. The next issue (November), as now planned, will contain articles on teaching by a mathematics professor, an engineering professor, and a specialist in higher education, representing universities in three widely separated regions.

A word of appreciation is in order for those who have contributed articles. Appreciation is due also to those unnamed contributors who have passed on something vital to their fellow teachers. Ideas are pervasive and fecund. No one can reckon how far their influence may reach.

4 William S. Learned and Ben D. Wood. *The Student and His Knowledge.* New York: The Carnegie Foundation for the Advancement of Teaching. 1938. Page 57.

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TEACHING AN INTEGRATED COURSE IN THE BIOLOGICAL SCIENCES

By

W. R. Hatch and H. K. Buechner

Under the spur of student interest and the promptings of a small faculty group imbued with the spirit of integration, we have been teaching an integrated course in the biological sciences at the State College of Washington since 1946. Accordingly, we have had opportunity to experiment with the teaching procedures and slowly to evolve our handling of a one-semester course which has grown on us as it grew up.

We have taught bona-fide integration from the word "go." We survey the biological sciences, but not in the common hyphenated sense (botany-zoology). We make use of principles, but the priority that we give to these principles gives the course a flavor different from that of the usual principles course. While a good course for non-majors, and hence a desirable course in general education, we have designed it to provide a good introduction to professional courses in the several biological disciplines.

The cardinal or first principle that provides the basic pattern of the course and governs the presentation of the material and the examination of the students over this material is the holistic hypothesis. What we aim to do in the course is to discover the major biological "wholes." The course has a simplicity of structure and the least endowed of students can follow the outline without too much difficulty. The method of presentation is governed primarily by our conviction, which is supported by our experience, that integration is something the student must discover for himself. To this end we use lectures, weekly conferences, and examinations. There is a clear and unmistakable method in our presentation. We use the lectures simply to present the facts. We do not in these lectures attempt to generalize or interpret, but leave the process of synthesis or integration to the students in their weekly conferences. The examinations, in turn, are designed to test the students' ability to integrate the material, and their grade is a measure of the size of the whole they find in a given body of fact. Their grade is always represented to them as a fraction of some whole.

The method used with any block of material involving lectures, conferences, and an eventual examination, is repeated with each block. Our first block, for example, deals with the "Nature of Life" which in turn is split into a consideration of (1) the Structure of Living Things and (2) the Activities of Living Things. Using the scientific method as a tool of instruction, we first state the problem. For the structure of living things our problem is: "What is the *essential* structure of living things?" We then analyze the problem in the lectures, slowly cutting our way through all that multiplicity of structure associated with plants and animals. By our analysis we are able to show the student that the essential structure of living stuff is not to be found in its organization into organs or tissues. This analysis is reinforced in conference. We reach this conclusion by providing the student with a simple classification of living things. An appreciation of what animals and plants are suggests that the essential structure of any living thing must be that structure associated with every living thing—large and small, multicellular and unicellular—and must eventually be found in the least of living things, even in entities as small as the virus.

After consideration of organs and tissues as the essential structure, we have a long look at cellular organization. To assist with this analytical problem, we present the cell theory. Under sharp questioning in the conferences the student discovers that an evaluation of the cell theory requires a definition of terms. "What is a cell?" "What is cell division?" A very careful analysis is made of cell division, that synchronization of cytoplasmic and nuclear division that produces uninucleate masses of protoplasm. But protoplasm may also increase its mass in other ways. It may employ free-nuclear division where there is no synchronization of cytoplasmic and nuclear division. The two processes are different; the products are different. If the first is a cell, the second is something different; if the first is cellular, the second must be noncellular. So by an analysis of syncytia and plasmodia in plants and animals and by a consideration of the techniques used by different organisms to increase their mass, we discover, as modern-day cytologists have dis-

covered, that it is illogical to conclude that living things always have cellular organization.

By these analytical means we cut through cellular organization and find that only in protoplasm can we expect to find the essential structure of living entities. Protoplasm now becomes our target, so we study its microscopic structure as that is revealed in comparative cytology. We then hold the microscopic structure of protoplasm to the test. "Does it constitute the *essential* structure of living things?" The facts of microscopic structure have been presented in a series of representative types in which the cytological details of vertebrate and protozoan cells, of flowering plants, of unicellular green algae, of blue-green algae, of bacteria, of fungi, including the synctial types, of a myxomycete, a plasmodium, and of the virus are critically explored. This represents depth and breadth and is as up-to-date as Max Delbrück's researches on the phage.

In the presentation of this series, the same colored chalk is used for the same microscopic structure. The material is presented without interpretative comment. In the conferences that follow the student is asked: "Is the *essential* structure of living things to be found in microscopic structure?" The student, in this initial invitation to do some thinking for himself, usually reacts like an abused animal and looks up at you with pleading eyes. But when you suggest that he does not need to possess a high I.Q., that he is under a real disadvantage only if he is color blind, the student stops protesting long enough to discover that the only color used in our "chalk-talks" in every instance was the original color of the blackboard—that is, there are no microscopic structures common to all protoplasm and hence if he is looking for a structure in any and in all living things he must look further. Confirmation that the essential structure of living stuff must be ultramicroscopic comes from his analysis of nuclear structures where, as the student follows along from nucleus to chromosomes to genes, he finds in genes the only structures consistently identified with every living thing. It dawns on him that the gene is ultramicroscopic. In this way the student learns how to approach a biological problem and how to analyze it, winnowing out that information which is relevant to the problem at hand.

The next facet of the scientific method taken up in lecture is observation. Here our expanding ability to observe ultramicroscopic structures and particularly the ultramicroscopic structure of protoplasm is developed. The application of the Tyndal åffect to the dark-field microscope, the results obtained from X-ray and polarized light, and the electron microscope are considered. The student is next asked to dig out the properties of protoplasm as these can be got at by micromanipulation and certain direct tests.

We next shift abruptly to a consideration of work done with colloids and particularly the work done on colloidal gels. In the conferences we ask the student to interpret these facts and by comparing the properties of protoplasm with the properties of colloidal gels to develop his own hypothesis as to whether there is an ultramicroscopic structure to protoplasm. If there is such a structure, what is its presumed organization and what is its presumed chemical nature? In this way, the student discovers for himself his first whole, namely the protein-molecular-network hypothesis of protoplasmic structure. The implications in this study and in this hypothesis are explored by questions that look toward the explanation of the soling and geling of protoplasm—its elasticity and its conductivity.

Our pedagogy is the scientific method and the student becomes habituated to it. By the use of very simple and graphic techniques he learns to take his first uncertain steps and finally finds himself analyzing problems, assembling and interpreting his facts, seeking always some explanation that combines these facts into some biological whole. Actually, he discovers hypotheses or theories long before he has a name for them. When the student is tested on this material we try to show him that he has, in fact, been discovering a biological whole and we use some statement of the holistic hypothesis to demonstrate to him that scholarship involves the search for wholes and that a subject matter can finally be shown to be whole. Since the examination is a teaching device with us as well as a measuring stick, a few questions from a sample examination may give the reader a better measure of the course and this part of it than a detailed exposition.

Examination

"To the young mind everything is individual, stands by itself. By and by it finds how to join two things and see in them one nature; then three, then three thousand; and so, tyrannized over by its own unifying instinct, it goes on tying things together, diminishing anomalies, discovering roots running under ground, whereby contrary and remote things cohere and flower out from one stem."

—Ralph Waldo Emerson, *"The American Scholar."* [1]

[1] *Complete Works of Ralph Waldo Emerson*, 6 vols. Boston: Houghton Mifflin Company, 1921. Vol. 2, p. 85.

A common stem for all the separate facts bearing on the structure of living things is found in the protein-molecular-network hypothesis.

3. How can we be sure that the essential structure of living things is not to be found in cells, in epithelial or bone cells, epidermal or cortical cells?
4. How can we be sure that the fundamental structure of living things is not to be found in microscopic structures such as centrosomes, golgi, mitochrondria, or nuclei?
5. What facts, supplied largely by the chemist, lead us to conclude that the ultramicroscopic particles in protoplasm are protein molecules?

Let us next join certain other facts which, together, diminish certain diological anomalies.

7. What is the explanation for the fact that in the human body at one and the same time we have uninucleate (bone cells) and multinucleate (striated muscles) masses of protoplasm?

Let us next discover the underground roots joining contrary and remote things—things as contrary and remote as animals like the cow or man on the one hand, and green plants like the apple tree or wheat plant on the other.

10. What is the evidence that vertebrate animals and flowering plants have a common origin?

The next block, the Activities of Living Things, completes our analysis of the nature of life. It is introduced by a problem. Here, as before, an attempt is made to present all the pertinent facts, including current research. Here too, we insist on breadth as well as depth, and we again urge the student to apply the test of inclusiveness.

In conference the student is again asked to marshall and interpret his evidence. Here he assembles and evaluates the autotroph hypothesis and then the heterotroph hypothesis. He then has what it takes to develop his own hypothesis as to the origin of life. For documentation he must use not only the facts he has just acquired about the activities of living things but the facts of protoplasmic structure. This impels him to reach back for the structural as well as the physiological pieces of this great jig-saw puzzle.

The search for wholes and the meaning in wholes, once found, is illustrated in our presentation of growth as a physiological attribute of living things. The need for some whole becomes apparent as soon as one becomes at all critical about growth. We provide a definition: "irreversible increase in mass." We begin to ask questions: "But how do organisms increase their mass?" The student is alerted to the significance of the word *organism*. Has he explanations that take into account the world of living things from man to virus? Has he a whole explanation?

We next help the student dredge up the facts he already has, namely, cell division and free-nuclear division, and go on from there. "But what makes a nucleus divide?" "What makes cytoplasm divide?" This takes us on into the nucleo-cytoplasmic ratio. "Why do we have such a ratio?" This, in turn, leads to protoplasmic synthesis, to the role of enzymes, and to the ultimate role of genes, and so growth emerges as a cytological whole. Beyond this lies the scale theory, the chemist's explanation for these phenomena.

To show a third supporting whole, growth is presented as an organismal response. The problem of embryological differentiation is a case in point, for in the process of specialization of parts and functions it is clear that the cell is originally generalized, not specialized. When we move it from one location to another in the embryo at appropriate times and in appropriate ways, the cell has the potential for many different structures and functions. The specific functions and structures which it ultimately assumes are determined by its climate of chemical regulators. The cell is a whole before it is a part. That growth is an organismal response is shown when one follows the waves of growth and the patterns of cell division that effect evagination and invagination in embryology, because here it is clear that the organism and not the cells is "calling the shots" and that there is an organismal pattern to growth in both space and time.

Growth in plants is another good illustration here. The following is apparent: auxins produced at the tips of stems affect and coordinate the growth of root tips; if the synthesis of the auxins is taken into account, the root tips by supplying minerals and water affect the stem tips; and all parts of the plant, in fact, some dead, others incapable of growth, all contribute to growth directly or indirectly; there is an organismal design.

The role of the whole is again illustrated in reproduction, particularly in sexual reproduction. We state our problem: "What makes sexual reproduction sexual?" "Is it structure, is it organs, tissues, cells, or is it some cellular component?" "Is it a process or processes?" "Is it copulation, conjugation, pollination, fertilization, gametogenesis, sporogenesis?" "Is it cell division,

is it mitosis, meiosis, or is it karyogamy?" We make it clear that they will have to discover the answers for themselves. The answers are not too hard to come by once sexual reproduction is discovered for what it is, and what it is is developed in another "chalk-talk" featuring man, paramecium, the apple tree, and chlamydomonas. Our schematic presentation explores every parallel structure and function, but we do not point them out.

Sexual reproduction is not what students think it is. That sexual reproduction is a nuclear phenomenon comes as quite a blow. Since this is a new idea (at least new to them) we ask them, in seeming disbelief, for their proof. And so they analyze the data for us. By this time they are becoming both more competent and more confident. In this way we discover the processes of meiosis and karyogamy, the only processes common to all sexually reproducing organisms. Meiosis, that volatile subject that evaporates quickly from most young minds, stays with our students because they discover it and only after hard work. Then, of course, we have to search for the significance of meiosis and karyogamy, discovering as one must that change is inherent and inescapable in sexual reproduction. But what about these changes: "Are they advantageous to organisms, disadvantageous, or neutral?" They prove to be random changes and yet organisms seem to extract advantage from them. Then the question arises: "How are random changes made advantageous to organisms?" In this way, we discover adaptation and its significance and, as a consequence, we get our first glimpse of that great biological synthesis, the theory of organic evolution.

The nature of the examination over this section of the course is suggested by the following example, which again makes use of a statement of the holistic principle:

Examination

"Life is a single stream of matter and energy."
—Burton E. Livingston.

1. At the headwaters of the stream of life, what matter would we find flowing in the very first trickle? (Describe its structure.)
3. What causes the stream of life to swell? In other words, how do we account for the fact that while perhaps only a single gene flowed in the stream of life initially, that life subsequently was manifested in organisms with more genes and then, progressively, still more?
5. The water flowing in a stream falls from the clouds. Where did the energy come from that flowed in the protoplasmic stream in those headwaters where there existed only:
   a) A virus-like organism?
   b) An organism like our present day sulfur bacteria?
   c) An organism like our present day purple-sulfur bacteria?
7. You produce energy by falling water against turbines. How do we get energy out of food in protoplasm?
8. You need dams and turbines in the first instance, what do you need to have in protoplasm to release energy?
9. How can we be sure that life is a continuous stream from the past to the present?
13. It is presumed that the nature of the living matter flowing in the tributaries changed very slowly—that the first living things changed very slowly—but that all of a sudden the stream hit a steeper gradient and the nature of living matter began to change faster and continued to accelerate all the way to the mouth.
   a) In the stream of life, why did the first things change so slowly?
   b) What occurred in the stream of life to accelerate the change?

The principles discovered in this block of the work include the autotroph and heterotroph hypotheses, the Free and Horowitz hypotheses, the theory of biogenesis, the theory of organic evolution, and, of course, the holistic hypothesis.

The next two blocks of the course deal with what we call the "whole animal" and the "whole plant." In these we try to show that the overriding consideration, as we try to define an animal, is the integration of development, structure, and function at all levels. The concept of the whole animal is developed first in man. This is a synthesis of embryological and postembryological development, of anatomy, of histology, and of physiology. This we integrate around the circulatory, nervous, and endocrine systems. In our examination we take a part, a very small part like a protein molecule in a fibril of striated muscle, and try to show the dependence of this single entity on the integrated and interrelated responses of the total body. Starting out with the newest information on the nature of muscular contraction, we tie the molecule in the muscle into the whole body. Finally, we ask, with some assurance that we will get the correct answer: "In this examination does the finger write or does the body write?"

Examination
The Whole Man

Socrates said, "Know thyself." To know one's self in a biological sense, one has to understand the coordinated interrelationships that exist between one structure and another, one function and another, and between function and structure. One way to test our understanding of these dynamic interrelationships is to take one small part and explore those ways in which that part is dependent upon other parts and the functions of other parts. Let us, for example, take a protein molecule in a fibril of a striated muscle in your index finger as you write this examination.

1. What is there about the structure of this molecule which is believed to account for its ability to contract and extend itself?

3. If the protein molecule is to continue to contract, it is dependent upon the following (Note: These dependencies are actually infinite; in this examination most of the alphabet is used to list a representative sample):
   A. The Pancreas
      1) In what way is the protein molecule in the finger muscle dependent on this gland?
   I. Arterioles (small arteries)
      1) How do the arterioles increase the supply of blood and hence of sugar to the finger muscle?
   L. The Kidney
      1) The kidney also helps maintain the constancy of the internal environment of the body and of the finger muscle. How?
   N. The Brain—the contractions of the muscles in the finger have to be coordinated.
      1) What part of the brain routes nervous impulses to the correct number of muscles so that you can form letters with your pen?
   S. The Adrenal Glands
      1) Through what system are the activities of the finger integrated with those of the adrenal glands?
   T. The Gonads
      1) Why (apart from Jergen's Lotion) are a girl's fingers soft, white, and feminine while those of a boy are rough, red, and masculine?
   U. Chromosomes
      1) What is the difference between the chromosomes in the nuclei of striated muscles in a girl's and a boy's finger?
   W. Organic Evolution
      1) How did something like a prehensile (grasping) finger happen?
   X. A horse's hoof, a bird's wing, a whale's flipper, and a frog's foot all have five digits (fingers) just as you have. Why?

Man is whole, but the wholeness of animals may not be apparent even though the situation is much simpler in unicellular forms; so we study the nature of the whole in the protozoa, discovering that you can get specialization of structure and function even in a single cell.

The whole plant is treated in an entirely comparable and parallel fashion. The small part whose dependencies we explore— the part which must be integrated into the whole—is either a chloroplast or a mitochrondium and here we end up on the same note: "Does a chloroplast, for example, achieve photosynthesis or is photosynthesis achieved by the plant?"

Examination
The Whole Plant

Life is an expression of functional unity in which the parts cooperate in the maintenance of the whole in continuously changing surroundings. To better appreciate the interrelationships of the parts of a plant we might well take one small part, namely, a chloroplast, and explore the nature of its dependence on the cell in which it is found and on the other cells, tissues, and tissue systems of the plant.

8. The proper functioning of a chloroplast requires that it be supplied with carbon dioxide and oxygen. How do the spongy cells of a leaf assist in the movement of carbon dioxide through the leaf?
13. The proper function of a chloroplast requires that it be supplied with water. How do the spongy cells of a leaf assist in the movement of water through the leaf?
15. Through what cells and in which tissue system is water transported through the veins of the leaf?
17. What force accounts for the movement of the water up through a stem and out in a leaf? Explain the force.
18. What physical property of water makes this movement possible?
19. Ultimately the chloroplast in the leaf is dependent upon the roots to absorb water from the soil. While roots may be 30 feet in length from trunk to root tip, over how much of this surface can water be absorbed?
30. We say we need to understand development to understand the function of an organism. How in the process of development are long threads of water formed in vessels?
31. Where does the original water in vessels come from?
35. How does respiration in the cambium of a root affect the photosynthetic function of the chloroplast?
36. How does the growth of a stem tip affect a chloroplast in the leaf?

The last block of work is in preparation for the final examination. In this final synthesis we use an evolutionary thread to string all of our facts, hypotheses, and theories into a full-bodied whole and even the student who is lost in the misery of his examination realizes that here is one course that hangs together; and that wholes have real significance not only for the professor, but for the student.

FINAL EXAMINATION

A good understanding of biology is to be found in the commonplace. Let us take a good look at some of those things we take for granted; a green leaf, for example. The history of a green leaf, in a very real sense, begins with the first photosynthetic organisms.

4. What photosynthetic pigments did the first photosynthetic organisms presumably have?
5. Are we to conclude that these photosynthetic organisms were the first living things on earth? Explain your answer.

The first green land plants existed as films of protoplasm that hugged the ground or the rock, as the case may be. If, in competition with other green films they were to be more successful in exposing their chlorophyll to light, they had to grow up into the air and this they did, forming short, cylindrical stems an inch or two in length. These stems became progressively taller and continued to branch.

8. When these stems were elevated, what tissues can we predict must have evolved to enable the plant to support life some inches above the wet ground?
9. Ultimately, leaves appeared on these stems. What is there about the structure of leaves today that bears testimony as to the manner of their origin?
10. What biological process must have evolved to account for the accelerating speed of the changes that brought about these improvements in a plant's ability to expose its chlorophyll more efficiently?
11. By what process can change be made advantageous to plants as it has in this case?
12. The changes which made plants progressively more efficient photosynthetically were achieved by random means. What are these random means?
19. In what respects is an apple leaf a more efficient organ than the photosynthetic stems of its ancestors?
20. What disadvantage is there to a plant in having a broad thin leaf?
21. What adaptations has a leaf made that makes these disadvantages less damaging than they otherwise might be?

ONTOGENY OF THE COURSE

Our teaching of an integrated course in biological sciences came as a direct result of the second meeting of the Pacific Northwest Conference on the Arts and Sciences[1] held on our campus in 1944. Members of Mortar Board, senior women's honor society, served as hostesses and secretaries at that fateful Arts and Sciences conference. This student group caught the fire too, but with them the conflagration was more general than with the faculty. They circulated questionnaires to their fellow students, and they discovered in the process that there was real student support for a program of integrated courses.

The actual birth of the course was precipitous. Late in August of 1946 the administration concluded that the time to enter upon this program was now and so with only a few weeks' warning two of us undertook to develop the biology course. Only one volunteered to teach the course in the social sciences, three were commandeered for the humanities, and four were drafted for the course in the physical sciences. The president and the vice president were committed to the program in principle and gave the biology course their endorsement, even to the extent of freeing time through a staff appointment. There was, however, little enthusiasm for the course, or for any of the integrated courses in the dean's office; and two of the three chairmen of biology departments were openly antagonistic. The course was offered, however, and it was offered as a bonafide integration, because the instructors insisted that they would have to teach it as an integrated course, or not at all. In the division of biological sciences at the outset, there was very general skepticism; in some quarters, outright opposition and even sabotage. The course thus had to make its way in a climate that could scarcely be described as salubrious.

During the initial semester the course almost foundered, because the instruction was divided between two individuals. The difficulty was not that the instructors could not reconcile their differences as to either the principles or the factual content; the difficulty was simply that there were two instructors and the students spent too much of their time comparing and contrasting the two presentations. Beginning with the second year, this situation was corrected, and one man accepted the responsibility for all the lecturing. Later, the animal materials were farmed out to a zoologist in all sections, but this development did not come until the pattern of the course was well established.

The evolution of the course through the next few years saw some interesting changes. In the earlier semesters instruction was given in lectures only, and in these lectures the instructor not only presented the factual information but made all the analyses and syntheses himself. The integrating principles (the theories and hypotheses) were discovered by the instructor and presented as *his* distillation of the facts. This kind of teaching proved ineffective, because so long as the integration was done by the instructor, the student accepted no responsibility for it and simply learned to make memorized re-

[1] In 1949 merged with the Pacific Northwest Conference on Higher Education.

sponses. Furthermore, the student was denied the thrill of discovery. Integration to be meaningful to the student has to occur *in the student.* Conferences then were organized to supplement the lectures. Ultimately, the lectures simply became the place where the factual information was presented.

The conference underwent changes as we experimented with it. At first it was just an adjunct to the lecture, but as time went on it became the most substantial and most significant hour of the course. Initially, the conference was scarcely more than a recitation period in which we ground the facts into the students. We next experimented with demonstration-conferences where the student could acquire first-hand experience with the materials. Progressively, however, the emphasis shifted more toward a true conference where the student took his facts and tried to analyze and interpret them for himself. The staff at first was most inept in handling these conferences because it persisted in doing too much of the student's thinking. Under the necessity of having to meet six or seven or even more conferences a week, the instructors slowly learned to develop conferences in which the student did his own thinking and his own interpreting.

In the early days of the course we prepared study sheets and then abandoned them. Next we organized reference shelves but soon abandoned them also. Study sheets and reference shelves did too much of the student's thinking for him. A modified reference shelf developed during the later years has been more effective. It consists of eight to ten books which critically develop or present convincingly the more important biological theories and hypotheses. These books include:

Beadle, G. W. 1949. Genes and biological enigmas. Yale University Press, New Haven, Conn. pp. 184–249 (see pp. 242–244 for Horowitz hypothesis). This is Chapter IX in "Science in Progress," Sixth Series. Ed. by George A. Baitsell.

Horowitz, N. H. 1947. On the evolution of biochemical synthesis. Proc. Nat. Acad. Sci., 31:153–157.

Huxley, Julian. 1942. Evolution the modern synthesis. Harper & Brothers Publishers, N.Y. 645 pp. (see pp. 13–28 for the theory of organic evolution).

Oparin, A. J. 1938. The origin of life. Translated by Sergius Morgulis, Macmillan Company, N. Y.

Seifriz, William. 1936. Protoplasm. McGraw-Hill Book Co., Inc. N.Y. x + 584 pp. (see pp. 525–526 for Free hypothesis).

——————, Ed. 1942. A symposium on the structure of protoplasm. A Monograph of the American Society of Plant Physiologists. Iowa State College Press, Ames, Iowa. vi + 283 pp. (see pp. 1–9 for the protein-molecular-network hypothesis).

Sharp, L. W. 1943. Fundamentals of cytology. McGraw-Hill Book Co., Inc. N.Y. 270 pp. (see pp. 11–21 for the protoplasmic theory).

Tilden, J. E. 1935. The algae and their life relations. The University of Minn. Press, Minneapolis, Minn. vii + 550 pp. (see pp. 1–15 for the autotrophic hypothesis).

von Bertalanffy, L. 1952. Problems of life: An evolution of modern biological thought. John Wiley and Sons, N.Y. 216 pp. (see p. 148 for holistic hypothesis).

These books are shelved in the conference room and the students are referred to them only after they have discovered the theory or hypothesis for themselves. Here they can search out the wider implication and see the theory adequately stated and defended.

Although the students protested in the early semesters that we presented too many facts and asked them to do too much interpreting, we have steadily broadened and deepened the factual coverage and have required greater and greater competence in interpretation—not without protest, however. An emphasis that we have exploited in the latter years has been to use the newest experimental evidence available, trying in this way to give every subject matter the greatest currency we could. This means, in some instances, that we depend heavily on the newest research and even, in some instances, use research as yet unpublished.

One of the by-products of factual enrichment has been our discovery that we can develop in our students a good understanding of the phylogenetic development of the animal or plant body and the phylogeny of reproduction by using relatively limited series. As a matter of fact, it would seem that a very simple series enables one to get the essential principles across better than if the series are more complete, because the multiplicity of structure inherent in conventional surveys of the plant or animal kingdom seem to obscure the principles.

The true measure of achievement is qualitative. This measure, however, is difficult to get at. The solid satisfaction that the instructors now have is a measure of qualitative achievement and the more substantial quality of the examinations and the performance of the students on these examinations is another measure. But these measures are largely subjective. Perhaps the most objective measure of success is to be seen in the enrollment which has been shown in the tabulation on the next page.

A second measure of achievement is to be found in the fact that, while conferences in the

Year	Total State College Enrollment	Integrated Course Enrollment			
		1st Semester		2nd Semester	
		Number	Per cent	Number	Per cent
1945-46	3,961	145	3.7	......	....
1946-47	6,421	404	6.3	404	6.3
1947-48	7,201	392	5.4	322	4.5
1948-49	7,091	368	5.2	222	3.1
1949-50	6,567	304	4.6	214	3.3
1950-51	5,786	266	4.6	179	3.1
1951-52	5,177	270	5.2	126*	2.4
1952-53	5,377	288	5.4	213	4.0

* 1 section only.

course have always been voluntary and carry no academic credit, the students have attended them in greater and greater numbers. Initially, only a handful availed themselves of them. Our problem now is one of abundance. Almost every student appears at one conference and a great many students attend two, three, or even more conferences a week. As a matter of fact, this phenomenon has so impressed instructors of other introductory courses in biology that they are asking for our trade secrets. The easy explanation is that the conference attendance reflects the student's concern for his grade. This, in part, is true; but even this is a source of some satisfaction to us because it indicates that the student appreciates that he learns more about the course in conference than in lecture and that only when he takes a hand at his own education does he educate himself. The explanation our "doubting Thomases" would provide, namely, that this is an easy course, is simply not borne out by the facts, because the course has and deserves the reputation of being the most difficult introductory course in the biological sciences. That it is not a "pipe course" is borne out by the fact that the percentage of failures is at least as great as in the other introductory courses.

In the initial years we had to employ undergraduate assistants for the conferences. We slowly moved ahead into the use of graduate assistants specifically assigned to the course. When, for administrative reasons, it proved impossible to make this kind of assignment, we were reduced to using such graduate assistants as were available as donations from the several biological science departments. Our most substantial achievement came only in those years when we concluded that no compromise could be made in staff and put the best qualified staff into both the lectures and the conferences. This sometimes necessitated as many as 15 contact hours a week for one of the instructors, but the accomplishment was so obvious and the satisfaction so great that the burden was scarcely felt.

Our concept of integration has likewise changed through the years. At first, we sought integration in biological principles—i.e., in the more important theories and hypotheses. The role of these theories and hypotheses, according to our original prospectus, was that they made of the several biological sciences a single science, the science of life. Initially, our concern for these principles was somewhat superficial. A review of the old examinations shows that we questioned the students more on content than on principles. In the middle years, our growing concern for principles was reflected primarily in the final examination. We soon learned, however, that if we held our fire until late in the course the principles seemed more like an appendix than a substantial part of the course. Furthermore, as we lived with these principles we sensed there really was a hierarchy among them; some were more important, some less. A weighting of these principles led us to an ever greater emphasis upon holism. Holism at first crept into the course in that section dealing with the whole animal and the whole plant, but even here we scarcely gave it more than lip service at first. As its significance grew on us, we made it the concept that supported the whole course. Eventually, we even broke our way into the course by stating that our primary purpose was to discover biological wholes. Today this has become the guiding principle for all four integrated courses; each course in turn building toward a larger whole.

The Holistic Hypothesis

We have mentioned the cell theory, the protoplasmic theory, the protein-molecular-network hypothesis, the heterotroph and autotroph hypotheses, the Free and Horowitz hypotheses, the theory of biogenesis, and the theory of organic evolution. The holistic hypothesis, however, provides our primary integrating principle. Since it is not so generally understood as these other theories and hypotheses, we should like to develop it a little further and show its application to the course.

The whole, the object of our study and investigation, is the resultant of the interaction of parts or elements and represents a new phenomenon, a system, or an organism (using the term in its broadest philosophical sense as well as the more restricted biological sense) with inherent characteristics of its own. An appreciation of the holistic point of view and the recognition of wholes comes only when, as with the scientific

method, holism becomes an accepted way of thinking. The initial development of the concept is made early in the course in the discovery of the protein-molecular-network hypothesis of protoplasm, namely, structure. Here we deal with the interaction of thousands of atoms of carbon, hydrogen, oxygen, nitrogen, and sulfur producing a complex whole, the protein molecule. The interaction of protein molecules provides the basis for a larger, more complex whole and the interactions of the protein-molecular-network with solution (whole of many interacting parts) and emulsions (still other wholes) produce that complex whole which we call protoplasm. From this structure (of protoplasm) new activities emerge as physiologic characteristics of the whole—properties that do not reside in the elements, but in the whole are formed by them. Higher levels of integration are developed as the course progresses, emphasis always being placed on the relations existing between components as well as the parts. By focusing attention on relations and on the entire ensemble of components and their interrelations, meaningful wholes are more readily developed.

In the sections on the whole animal and the whole plant, emphasis is placed on the organismal nature of embryological development, growth, reproduction, and other phenomena. With a background of holistic thinking, the organismal concept is more readily developed.

The holistic concept serves as a guide and an aid in the achievement of real integration. It also helps to erase some of the artificial barriers between the physical sciences and the biological sciences on the one hand and the biological sciences and social sciences and humanities on the other. The ultimate objective is to develop in the student an appreciation for the relationships between the different disciplines and some understanding of knowledge as a whole.

Heart and Center of the College

"The frequent assertion that the Library is the heart and center of the College is the simple truth. All scholarly work, and all undergraduate study as well, consists either of the reading and interpretation of the recorded thought of the past or of the setting down of new information for the guidance of posterity. This is true of science as well as of the 'humanities.' Experiments made in laboratories are recorded, first of all, in notebooks and later in the learned publications of the science concerned."—Chauncey Brewster Tinker *in:* On Going to College, Oxford University Press, 1938. Page 294.

THE STUDENT'S BACKGROUND AND COLLEGE TEACHING

AN ENGINEER'S VIEWPOINT

By

GEORGE W. GLEESON

It is not inappropriate to repeat a listing of six major defects in education as published in a recent issue of the *Houston Post:*

> The teachers are afraid of the principal.
> The principal is afraid of the superintendent.
> The superintendent is afraid of the school board.
> The school board is afraid of the parents.
> The parents are afraid of the kids.
> The kids are not afraid of anyone.

The foregoing is but one of a number of similar examples of an educational "chain reaction." It may have its counterpart at the college level where the faculty, department chairmen, deans, president, regents, parents (also generous donors and members of legislatures), and the students themselves frequently exhibit reactions equally notable even though not the same. It is a common understanding that colleges place the blame for poor student preparation upon the secondary schools from whence it passes to the primary schools where, in turn, it is transferred to the parents. It is perhaps too much to hope that such criticism as is included in what follows may escape the oblivion always associated with the "buck passing" technique.

In the technical-professional college curricula, one person completes the requirements for a first degree out of every two who start. In engineering, for example, to insure a normal, yearly complement of 30,000 graduates, 60,000 young men must start an engineering program. In this time of acute shortage of technical personnel, and keen competition among the professions for the better high school student, the most fruitful field for recruitment is among those who are included under the repugnant phrase "normal attrition." Professional schools already have the young people, most of whom are from the upper half of their secondary school classes. To keep these young people is both a professional responsibility and an educational objective. Efforts must go deeper than the college pattern, however, and therein the "chain reaction" starts.

There appears to have been no comprehensive study of the causes of attrition since the 1937 bulletin "College Student Mortality" published by the U. S. Office of Education. Circumstances undoubtedly have changed since the foregoing date, but it is still quite probable that the same causes exist although in modified numbers. It is certain that the very factual causes of mortality, such as illness, finances, scholastic failure, and lack of discipline, still hold, and it is believed that the group classified as "causes unknown" is probably as large, if not larger, than previously reported. The latter group plus those who experience scholastic difficulty form a pool of potential candidates for graduation. It is the writer's opinion that students drop from the technical-professional patterns or experience difficulty therein primarily for one reason. They lack background.

IMPROVING BACKGROUND

If college teaching in technical areas is to be improved, such improvement must be measurable in either the quality or the quantity or both of the technical graduates. We dare not increase numbers by lowering standards, especially when such standards are currently minimal and are not beyond the capabilities of the average individual. If we raise entrance requirements, we shall only aggravate the shortage of technical personnel. The dilemma might be resolved if the college freshman had a somewhat different background. Accordingly, the following suggestions are offered, not to start another "chain reaction," not in criticism, and not to shift responsibility, but simply to initiate improved college teaching at the point where such improvement must be born, namely, at the secondary school level.

In terms of the technical student's background, principally as developed at the secondary school level, three possibilities exist: Mortality among students in the technical areas may be reduced, a larger number of graduates might result thereby counteracting the shortage of technical personnel, and improvement in college teaching might be effected to enhance the quality of the technical graduate. At the risk of dogmatism, the suggestions which would alter student background as developed at the secondary level are enumerated. Since the following ten suggestions

rest upon the very qualities that our college students lack, they also constitute points requiring our special attention as college teachers.

► *Students are permitted to attempt to run before they have learned to walk.* Many students come to college with a glib but superficial knowledge of physical science. They are imbued with superficial information about atomic energy, jet engines, rocket propulsion, television, wonder drugs, and like developments. Yet, they have practically no understanding of the simple and basic fundamental concepts of physical science from whence such developments arise. Perhaps the glamorized descriptions of modern developments are useful as motivation, but they are not the substance of an introduction to physical science.

One major problem of the college teacher is to make clear to students that science requires plain hard work. You must first master (and by master is meant assimilation by the student to the point of unaided recall for proper usage in thought sequence) the simple, primary concepts; be able to express them in their proper quantitative magnitudes in the various systems of units; and understand the conversion from one system to another. Next, the simple concepts must be properly grouped into secondary concepts which are in all cases combinations of the primary ones. Such primary and secondary concepts may now be grouped into equations which, with proper understanding of the coefficients of equations, give expression to the simple physical laws. The simple physical laws form the backbone for the more complex statements. The primary and secondary concepts and the simple and more complex statements of law form the background for comprehensive thought.

Such procedure is the "learning to walk" in the field of science. The procedure appears obvious as an effective approach to science teaching, but evidently it is not as obvious as it appears. At least, there is little indication that current secondary school graduates who talk glibly about modern developments, although wholly superficially, have ever been taught the rudiments of physical science.

► *Facts of themselves are not important.* Obviously, a person cannot think in a vacuum. It is necessary that there be something to think with and something to think about. A fact once written, or recorded, or memorized, however, has value only by reference when such fact is used in a thought process. In far too much science teaching, the marshalling of facts is the end product, when actually it is only the beginning. Science teaching involves use of the facts in a thought process. If you can not think with the facts, then they are best left to repose in the text, the encyclopedia, or the library. The exercise problem, the comprehensive problem, the definite decision are the tests of science teaching. The walking, human encyclopedia is not a scientist. Accordingly, facts are wholly secondary; it is what is done with the facts in an analytical manner which is really important. Let the facts be few, simple, and straightforward. Spend the teaching time in providing an opportunity for the student to develop facility in thinking in terms of the facts, thereby gaining understanding.

► *Concepts need to be considered in their entirety.* Unless a basic concept of science can be considered in its entirety and in relationship to associated concepts, then it were better not taught. A fragmented concept of science is a half truth. Half truths result in half right thinking. The more fragmented the concept the more handicapped the student. Likewise, an isolated concept, even taught in its entirety, but unrelated to associated concepts, may have negative rather than positive value. The foregoing statement is perhaps more applicable to simpler concepts than to the more complex, and is accordingly a matter of concern in secondary education. Perhaps an example is called for.

For many years one of the questions on a pre-test has been, "What is work?" Where the question is answered at all, the answer is always the same: force x distance. Never in ten long years has any student deviated and answered with pressure x volume, or torque x angle, or temperature x entropy, or any of the other products which might define work. Seldom do students equate work and energy and, of course, never do they present a comprehensive or concise definition. Their background instruction has limited their capacity for thinking about such a simple concept as work to one very specific and also limited example. Many students find it difficult to expand their thinking once they have assimilated a partial concept.

► *It is not as important that a student be proficient in something as it is that he be proficient* **with** *something.* Students in the technical areas commonly are proficient in mathematics but are unable to solve a problem, or they are proficient in spelling, punctuation, and grammar but are unable to write, or they possess a wealth

of factual information but are unable to reason with the facts. There is a world of difference between the prepositions *in* and *with,* and secondary education might well assume that its concern is with the utility aspects of subject fields.

▶ *A student learns only from what he does and from all that he does.* The term "learning" as used in the above statement excludes learning by rote. The term "does" implies an experience: the participation of the student in a situation wherein his effort controls the outcome. The more comprehensive, the more realistic; the more integrated the experience, the more learned. Obviously, the experiences must be progressively more difficult and repeatedly related to past experiences. It is the responsibility of the teacher to provide the situations and then act as a guide as the student is exposed to the experience. To talk or write about something, to rehash facts, to memorize, or to read a text can hardly be classed as an experience. The student must have some responsibility other than accomplishing a routine.

It is necessary that the student of science, particularly at the elementary level, be a participant in a progressive series of properly formulated experiences which are meaningful to him, in which he has sustained interest, and which provide by virtue of the participation a lasting impression such that under similar circumstances he later recalls the thought processes and the reasoning involved in the experience rather than the isolated facts. Fortunately, the facts involved are frequently recalled by association with the thought process.

▶ *Early advisement regarding the requirements of professional fields is essential.* Advisement programs in secondary schools have improved markedly in the past few years. There appears to be opportunity for much further improvement, however, as far as the technical-professional fields are concerned. By far the majority of potential engineers and scientists still believe that the professional work involves manual skills, and that material things are the focal points of study. For example, they do not realize that the aeronautical engineer will probably never fly a plane and, for that matter, may never see the plane which results from his design. An automotive engineer is not in any manner concerned with the activities of the "hot rod" enthusiast. A radio "ham" is far removed from an engineer in the field of communication. The work of the engineer and scientist is "head work" and not "hand work." Planning and design on paper by the application of the principles of science, primarily mathematics, physics, and chemistry, constitute the bulk of professional activity. The material things which result from such planning and design are the end product upon which, by the time they reach physical reality, the engineering has been completed.

There are other aspects of the technical-professional fields similar to the above example. Advisers must be sufficiently familiar with the attributes and requirements of the professions to offer realistic and factual advice at as early a point in the student's career as possible. Such advisement must be something more than a "career day" meeting or an initial "advisement interview." It should be a continuous process for as long as the student maintains a fixed objective.

▶ *Facility with modes of communication is essential.* Everyone appears to be in agreement as to the importance of secondary school instruction in English. In any technical-professional field, proficiency *with* English is an absolute essential. Such proficiency should be *with* both writing and speech. However, communication by graphics and through the language of mathematics is also important. In fact, to the engineer, mathematics serves in large part as an exact, quantitative mode of expression. The graphical representation is the equivalent of the mathematical expression but in a different form.

▶ *Evasion or substitution activities cannot replace requisite study patterns in preparation for professional careers.* Much of the "recreational" or "hobby" type of activity in the secondary school has attained a position of too great an importance in the thinking of the student. In his college career in the technical-professional areas, he will find little time to devote to such activity. Even under advisement, many students are unwilling to forego the type of pursuits to which they have become accustomed, and their academic careers suffer accordingly.

▶ *As in all fields, ethics, honesty, and mortality cannot be divorced from professional competence.*

▶ *Subjects and procedures associated with science should be included in science teaching.* There is a long list of items of daily living which are closely associated with science. Where possible, the principles of science should be illustrated by reference to those objects with which the student is or should be familiar. In such reference, the technically correct designation of

the item or object should be made with such description of the characteristics as will establish correct nomenclature, size, or physical and chemical properties. For example, few freshman engineers distinguish between cement and concrete, or iron and steel, or know the designation of nail sizes or types, etc. It is seldom realized how much "side issue" information can be learned when such information is only incidental to a problem in physics or mathematics.

Correction Never Fully Achieved

The foregoing statements of teaching practices or student procedures when associated with many other environmental factors or situations, personal, scholastic, or otherwise, establish a student's background. It is upon such background that education in the technical-professional areas must be superimposed. It would appear obvious that the scholastic achievement of the student at the college level would be related to his total previous experiences, and would be either enhanced or handicapped thereby. Particularly is this true in the initial contacts with the subject matter of technical patterns. Lack of understanding of basic fundamentals, inability to reason when confronted with simple situations, poor habits of workmanship, inaccuracy, lack of stick-to-it-iveness or patience, an indefinite or fictitious pattern of interests, inability with concise expression, and many other negative attributes of background may dictate the fate of the embryo scientist or engineer.

Real efforts are made to cushion the initial shock of transition from secondary school to a college technical pattern. Remedial classes are conducted, secondary school subject matter is reviewed, initial outside assignments are moderated, advisement is offered, proper study procedures are suggested, etc. There ultimately comes that time, however, when the student must become adjusted to the technical program and make progress therein. If his past habits and practices have become so set that he cannot make the adjustment, then from the start his scholastic career is in jeopardy. His background may be largely responsible for his difficulties or actual failure.

It is hoped that the foregoing is sufficiently concise to indicate that the college technical-professional areas inherit from secondary education some very real problems related to student background and attitudes. This heritage is restrictive in the sense that time and effort are consumed in correction, and such correction is never fully achieved within the limitations of time. Most certainly, such background development as can be effected at the secondary school level will be reflected in improved college teaching.

Larger Dividends

"Nothing would pay larger dividends than for faculties to become students, both of the art of teaching and of the materials of instruction."—Lotus D. Coffman, The State University: Its Work and Problems. University of Minnesota Press, 1934. Page 17.

WHAT IS GOOD COLLEGE TEACHING?

By

Hobart F. Heller

"Teaching is *best* when the students are active, interested, attentive, and when that to which they are giving their attention is part of a unit which is genuinely practical, morally stimulating, or culturally interesting. Teaching is at its worst when the members of the class are inattentive, either passively bored or outright disorderly, and when that to which they are *not* giving their attention wouldn't be worth attending to anyway. Between these two extremes I would not attempt to establish a scale."

This rather flippant statement, written to crowd into a one inch space an answer to the question "What is good college teaching?" when it appeared on a questionnaire recently, is taken as a text for this paper, because in focusing attention on the behavior of the members of the class it gets at the test of good teaching. The task of the teacher is to set the stage so that every student has the most favorable conditions for learning and to provide the leadership necessary to create the desire to learn.

Henry Johnson has said that all he knows about teaching can be stated as "Get the material to be learned into the direct experience of the pupil."[1] Palmer, whose essay is still worth reading, said ". . . a teacher must have an aptitude for vicariousness, . . . labor imaginatively himself in order to diminish the labors of his slender pupil."[2]

If, in evaluating the quality of teaching, one had to rely on a single visit to the classroom, certainly he would regard the attention paid by members of the class to the work at hand, together with the manner in which the attention was secured, as one of the best criteria. Good college teaching makes the student give his attention because he recognizes and respects the intrinsic worth of the class exercise. Good teachers do not need to hold attention through fear, nor through nagging; neither do they need to turn handsprings, that is, resort to a running fire of "wise-cracks" unrelated to the material at hand. There is dignity, and I do not mean stiff formality, in the leadership of the best teacher which puts him above such devices.

Good college teaching is business-like. There is a worthwhile job to be done. The teacher knows the job, has faith in its value, and knows how to get it done. College students are mature enough to recognize this and to accept his leadership. They have no need for make-believe or play. College life ought to have fun, play, bull sessions, all in their own places; but in the classroom there is work to be done. Of course, work can be done in a light-hearted manner; it does not have to be solemn, indeed it should not be. One need not literally "whistle at his work," but still the atmosphere can be pleasant and without tension. Meaningful work, pertinent to the aims of the course, and done in accordance with standards of good workmanship, not work assigned just to show how "tough" the course can be made, is indicated.

It is a corollary of this proposition that the good teacher works at his job himself. His assignments to students are not inspirations of the moment; they are thought through carefully; often they are experimented with to make sure that they are tangible, practical, and pertinent. He prepares for his classes with care, planning his strategy to fit the concepts to be mastered and the students who are to master them. He gives much thought to the creation of examples to illustrate abstract principles under discussion. He puts in busy office hours working with students, usually on their initiative. He does not "kid himself" into thinking that he is working hard at *teaching* when he is merely working hard at his own intellectual hobbies.

As another corollary, the good teacher has respect for his job of teaching. He knows that the classroom is the heart of a college. At the same time he has perspective enough to see that *his* subject and *his* class are a part of a much larger whole in which other subjects and other activities than those of classes must find their places.

A good teacher "speaks as one having authority." He always seems to have a wealth of scholarship far beyond the needs of the moment. He is articulate; he speaks simply and without affectation, using his "ten dollar words" only

1 Henry Johnson, *The Other Side of Main Street.* New York: Columbia University Press, 1943. Page 106.

2 George Herbert Palmer, *The Ideal Teacher.* Boston: Houghton Mifflin Company, 1910. Pages 8, 13.

with persons who are equally familiar with them and with whom their use makes for economy of thought. He is self-confident without being pompous, and has enough humility to feel a bit awed when contemplating how much he does not know. He gives the impression that he thinks straight, that he knows the difference between a fact and an opinion, between thinking and feeling, between a deduction and a guess, and that he knows the sun does not rise because the rooster crows. He is ready to admit it if there is something he does not know, and is ashamed of the admission only when that something is so common to the matter which he is teaching that he ought to know. He confesses his error when he has been shown to be wrong.

A good teacher looks at his course as a whole and sees there unity. He sees a small number of concepts to be taught, with interrelationships which tie them together so that they form a core for the course. He sees the hundreds of details as related to the core, some giving it form, others merely scaffolding to help in its building. He knows how fast and how much a student will forget; therefore he plans to so teach that the core is retained after the details have been forgotten. He tries to teach so that with the core will go something of his own faith in, respect for, and perhaps even love of, his subject, giving the student the feeling that the time was well spent, and that he earned something worth the keeping. He sees all the activities of the course, the class exercise, outside study, and conferences, as designed toward one end.

It is incidental to this that the good teacher is usually a strong believer in frequent tests, and in a substantial final examination. He gives these tests, not only for the purpose of assigning grades, indeed this may be only a minor reason, but for the purpose of using the close attention and intense interest which students feel while writing an examination to help to integrate the material of the course. Students almost invariably want to follow up their examination to know why they missed a question. The teacher who does not capitalize on this is missing a real opportunity. Occasionally a teacher will say, "I have such a small class that I'm not giving a final examination this quarter. I won't know any more about the students after an examination than I do now so why bother?" Perhaps he will not know any more about the students after the examination than before, but if the examination is well planned the *students* will know more. This assumes, of course, that the teacher does not write examination questions by use of a kind of "eeny-meeny-miny-mo" technique.

The good teacher sees the members of his class as individuals, each playing his own role in the progress of the class, and at the same time achieving his own growth. He knows that as an individual each student needs to experience the thrill of achievement, and he plans his assignments so that all but the hopeless can have that kind of experience rather than continuous frustration. He knows that as an individual each student needs recognition of his achievement, and he conducts his class exercise so that every student has his opportunity. He is sensitive to the reactions of his students, recognizing that the student over here who usually is not so "sharp" has an idea for once in his life, and that a student over there is on the verge of dropping off into a day-dream. He does not let his best and most brilliant students waste their talents on the obvious, but saves their power to contribute to questions that challenge it. He does not make assignments and then forget to check on accomplishment, for he knows that nothing is so conducive to negligence as is failure to account.

This is not to be construed as advocating that no student ever fails a course under a good teacher; it merely means that none should fail because of the teacher's neglect, and that the number who fail because of their own neglect is minimized by skillful leadership.

When college teaching is at its best, the teacher and students appear to be *working together,* with the teacher often serving, as one of my colleagues put it recently, as mediator between the student and his job. The good teacher knows when and how to help a student and when and how to put him "on his own." He has a kind of sixth sense which tells him how to keep out of the student's way when he is doing all right. Perhaps he even knows the rare occasions on which it is good to "slap him down," or "give him the brush-off."

There is no one personality which makes one able to teach effectively. Some good teachers are quiet in manner, not given to raising their voices. Some are vigorous in their approach. Some have a flair for the dramatic. These exterior manifestations do not seem to matter much. Students do have a knack for piercing exteriors, seeing what is beyond and responding to it. The "phony" does not "get by," but the genuine gains the respect of almost all. Nor is a good teacher

known by his method. Some can rely mainly on lecturing, if they are sensitive enough to the members of the class as individuals. Some rely on recitations, some on discussion, and others on various forms of laboratory or supervised study techniques. The best teachers are likely to have many methods, many techniques, many tricks at their disposal.

Good teaching has vitality. The subject taught by a good teacher appears fresh and exciting even though it be the twentieth time he has taught it. The good teacher does not sit back of a desk droning on in a monotone, oblivious of twenty day-dreaming students, nor does he pace up and down shouting in a high-pitched voice that never comes down. He does not sit back of his desk with a book open asking students to recite in alphabetical order until the assignment has been covered, reprimanding the students who did not know their lesson, assigning the next chapter, and dismissing the class. He does not conduct his class as a sort of glorified bull session in which topics unrelated to the work at hand fill the time. He does not assign the students some laboratory work to do and then go over to a corner to read. He does not waste the time of his students with an interminable succession of boring reports of projects half done. He does not have a twenty-year-old set of lectures with the jokes penciled in the margin.

It is often said that teaching is an art. If it is, then it is analogous to the art of conducting an orchestra. The conductor has a background of scholarship in music, and a long period of study and practice of the techniques of conducting. His score has all of the composer's directions. One might think that these would be sufficient; yet one can beat the time correctly, bring out the dynamics intended by the composer, see that every player plays his notes in correct pitch, and yet have the music elude him. There is something in an artistic performance that defies analysis and transcends measurement. It exists in a thousand infinitesimals, nuances of tone and phrasing. He who would achieve artistry not only must be a master of subject matter and techniques; he must have sensitiveness to and sympathy with his players, leadership enough to make them want to "tune in" with him, and the imagination, intuition, and judgment which tell him when something is just right.

A Cerberus

"A really good professor should be a Cerberus—three gentlemen at once. He should be able to teach; and though the desire to teach is strong and common, the power to teach, as we who try know, is slow of growth and rare in its achievement. He should be a good scholar; for . . . . . good teaching . . . . . seldom proceeds except from a mind trained in fruitful investigation, deep stored with knowledge, and creative in science, in criticism, or in the realm of the imagination. . . . Finally, the professor should be an admirably sane, admirably broad, admirably human individual."—Henry Seidel Canby, College Sons and College Fathers, Harper & Brothers, 1915. Page 63.

The Goodly Fellowship

"In a sense, teaching cannot be taught, since essentially it must be a flaming and an outgoing of the spirit. It is possible, however, that men and women who have succeeded as teachers can offer some guidance which will be helpful to the novice who has a latent capacity for teaching."[1]

On an early June evening a group of faculty people sat in a professor's home. Each had brought, from his experience and observations, some one pointer for a young college teacher. Thinking of young teachers entering the profession and looking for ideas on how to do a good job, these more seasoned folk gained a deepened experience of fellowship as teachers, "the goodly fellowship of those who teach."

PROFESSOR OF ENGLISH:

"I am reminded of a favorite story of mine. Toscanini had a musician who had such a 'sour puss' that he called him in and asked him, 'Do you like me?' 'Oh, yes, very fine, very fine.' 'Do you like the orchestra?' 'Oh, yes, fine orchestra, fine orchestra.' 'Then why is your face so sour?' 'I just don't like music.' I'm a teacher of literature, but you can apply this to your own field. Lots of teachers of literature don't like literature. You must have a liking for your subject. I say to my classes, 'Literature is the most important subject you are taking and the most important in your curriculum.' "

PROFESSOR OF PSYCHOLOGY:

"In my war experience I had some time away from the campus to think. I came back with a little different viewpoint. I came back with the idea that psychology is not the most important subject. So I try to prepare the student with more than psychology—to teach student psychology rather than merely teaching psychology to students."

PROFESSOR OF BUSINESS ADMINISTRATION:

"At the same time, I'd urge that the teacher confine himself to the field he is supposed to be teaching. Within reason, of course—not go too far afield."

ANOTHER PROFESSOR OF ENGLISH:

"Young teachers sometimes have confessed that they were always a little nervous on entering a classroom—have confessed this shyly as though it were somehow a defect. But where a feeling of nervousness is not clearly due to ineptitude, it is not a defect; it is a positive virtue. Experienced teachers, those regarded by their students and colleagues as 'good' teachers, have also, in their more engaging moments of un-Olympian frankness, confessed to a feeling of anxiety and apprehension as they approached the classroom door. With them this faint perturbation is not due to any sense of inadequacy, lack of knowledge or of preparation; it is due, I believe, to an awareness that they are about to embark upon an adventure, an agreeable adventure that is going to call forth all their powers. This is true whether the topic be the uses of the comma, the square of x plus y, or the philosophical implications of the second law of thermodynamics. Such an adventure ought to make even the oldest faculty member more than a little nervous, stepping up his pulse rate and pushing up his blood pressure another notch."

PROFESSOR OF PHARMACY:

"The most effective teaching has been the inspirational type that will stimulate the student to do a little bit more than we have required of him. We find that the teacher who himself has been inspired inspires his students. The teacher of any subject should be enthusiastic. I see no other way to make a success of the job of inspiration."

INSTRUCTOR IN PHYSICS:

"A young teacher may have an advantage in that, in age and viewpoint he is near his students."

ASSOCIATE PROFESSOR OF HYGIENE:

"A young teacher, I think, should try out different methods of teaching. He should try to find what methods are best for him and not just use those his teachers used."

ASSOCIATE PROFESSOR OF ZOOLOGY:

"My suggestion is: Assume that each of your students is an *adult* person. You will thus tend to evoke an adult attitude."

Continued on next page

1 Bernice Brown Cronkhite, *A Handbook for College Teachers.* Cambridge, Massachusetts: Harvard University Press. 1950. Page v.

These Books Were Stimulating

Books being read during the current year by members of a faculty-student seminar in college and university teaching are briefly annotated, in most cases by excerpts from students' reading reports.

American Association of University Professors, **Report of the Committee on College and University Teaching.** Washington, D.C.: Bulletin of the American Association of University Professors. 1933. Pp. 122.
"Study by the professors themselves. A very worth while publication."

Burnham, William H. **Great Teachers and Mental Health.** Pp. xiii+351. New York: D. Appleton and Company. 1926.
"Socrates, Jesus, Bacon, Vittorino, Trotzendorf, Commenius, Hall—they were simple and dynamic."

Barzun, Jacques. **Teacher in America.** Pp. 321. Boston: Little, Brown and Company. 1946.
"A wonderful humanistic version of teaching— unorthodox treatment."

Fitzpatrick, Edward A. **How to Educate Human Beings.** Pp. xiii+174. Milwaukee: Bruce Publishing Co. 1950.
Chapter VI "The Teacher and the Student" with its wide range and 46 references is a little book in itself.

Heaton, Kenneth L., and G. Robert Koopman. **A College Curriculum Based on Functional Needs of Students.** Pp. vii+157. Chicago: University of Chicago Press. 1936.
College curriculum, functional needs of students, methods and materials of instruction, evaluation.

Holder, Charles Frederick. **Louis Agassiz.** Pp. xviii+327. New York. J. P. Putnam's Sons. 1893.
"Picture of a wonderfully creative and human individual for whom learning and teaching were one and the same."

Hook, Sidney. **Education for Modern Man.** Pp. xiii+239. New York: Dial Press. 1946.
"A sensible little book and a much needed one. Excellent chapter on 'The Good Teacher.'"

Kelley, Earl C., and Marie I. Rasey. **Education and the Nature of Man.** Pp. xi+209. New York: Harper & Brothers. 1952.
Facts currently available about the nature of human beings as applicable to teaching and learning. Notable chapters on evaluation and method.

Kelly, Fred J. (Editor). **Improving College Instruction.** Pp.vi+195. Washington, D.C.: American Council on Education Studies, Series I, Number 28. Volume XV, July 1951.
"Probably the best single piece I read."

Klapper, Paul. **College Teaching.** Pp. xvi+583. Yonkers-on-Hudson, N. Y.; World Book Company. 1920.
"Old? Yes, but perfect as an introduction to study of college teaching."

Lynd, Helen Merrell. **Field Work in College Education.** Pp. xi+302. New York: Columbia University Press. 1945.
"I was especially interested in the case histories of students who showed signs of maturing as a result of their field work experience."

Palmer, George Herbert. **The Ideal Teacher.** Pp. vi+32. Boston: Houghton Mifflin Company. 1910.
"Teaching thirty-nine years in Harvard College, I have found each year a little more fully my own incompetence." Author's philosophy is still good, after a half century.

Rice, John Andrew. **I Came Out of the Eighteenth Century.** Pp. x+341. New York: Harper & Brothers. 1942.
"Very interesting . . . a nice job." Rice says: "A man is a good teacher if he is a better something else; for teaching is communication, and his better something else is the storehouse of the things he will communicate."

The Goodly Fellowship—(*Continued from p. 19*)

ASSOCIATE PROFESSOR OF PHYSICS:

"To a beginning college teacher I would say this: Remember that what you tell the student he will soon forget. But what he tells you he will long remember."

ASSISTANT LIBRARIAN:

"The word 'teacher' is associated in my mind with Dr. Edward O. Sisson, who was a professor at the University of Washington, and after a session as commissioner of education in Idaho was president of the University of Montana. He resigned to go back to teaching at Reed College. He told me that it hardly seemed right for any one to be as happy as he was on his return to teaching."

PROFESSOR OF BOTANY:

"One yard stick of teacher worth seems to me especially worthy of emphasis. Are you deeply and vitally concerned with the problems and success of your students as individuals? Or do your classes merely afford you the clinical material on which to operate? Students are not to be fooled. They respond to kindly interest as parched plants to a shower. If the personal touch means less to a teacher than the purely technical aspects of his subject, he is not in the proper vocation and would better qualify as a technical encyclopedia or mere purveyor of facts."

PROFESSOR OF CHEMICAL ENGINEERING:

"College students may be slow in getting their thinking gears in mesh, and if, while they are trying to shift gears, the external machinery of the classroom procedures moves too fast, the gears get stripped. Disorder and confusion result. A little more patience and a little more emphasis at the right points might enable more students to get their thinking machinery into gear. Please, Mr. Young Instructor, don't start students in high gear. Let them, with your help, make the usual shifts from low to high."

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